(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 849 101 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.06.1998 Bulletin 1998/26

(51) Int Cl.⁶: **B60C 11/11**, B60C 11/13

(21) Application number: **97310274.2**

(22) Date of filing: **18.12.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **19.12.1996 JP 339136/96**

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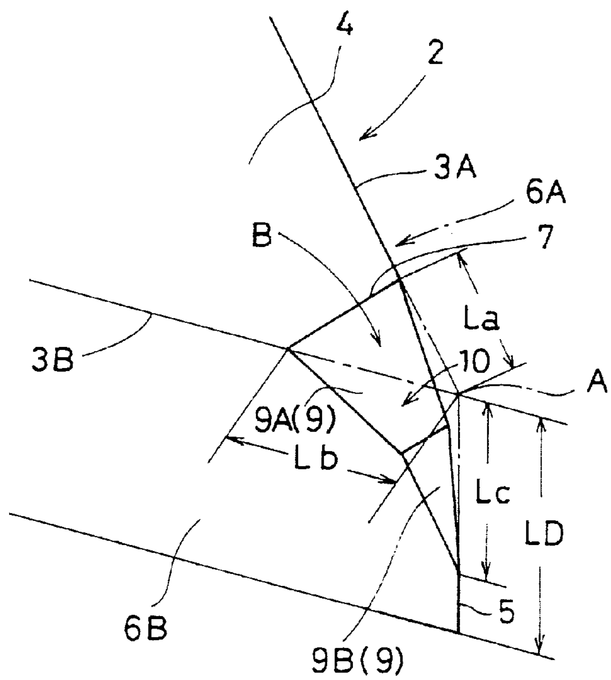
(54) Heavy duty radial tyre

(57) A heavy duty radial tyre comprises a tread portion (15) which is provided with blocks (2) having acute angled corners (B) each defined between a pair of edge lines (3A and 3B) of the block. The acute angled corners (B) are provided with a down slope (9) which becomes steeper from the radially outside to the inside of the tyre. Preferably, the size of the slope (9) is 1 to 10 mm along the one edge line (3A), and 1 to 10 mm along the other edge line (3B), and 5 to 13 mm in the radial direction of the tyre.

Fig.4



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Description

The present invention relates to a pneumatic tyre, more particularly to a heavy duty radial tyre with an improved tread portion having resistance to uneven wear and tear-off and improved wet performance.

In heavy duty radial tyres, e.g. truck/bus tyres which are required to display large traction, relatively large size polygonal tread blocks are widely used. In such a tyre, to improve running noise and wet performance, circumferential grooves and axial grooves are usually inclined. As a result, as shown in Fig.10, acute angled corners (b) are necessarily formed on the tread blocks. The acute angled corners (b) are worn or torn off relatively easily, which becomes a starting point of uneven wear.

The convention manner to solve this problem of uneven wear is to cut off the corner (b) by a single down slope (e) as shown in Figs.11 and 12. However, if the cut-off rubber volume is large, wet performance and tyre appearance or tread pattern image become worse. On the contrary, if the cut-off rubber volume is small, the resistance to uneven wear and tear-off is small. Thus it is not possible to satisfy such irreconcilable requirements.

It is therefore, an object of the present invention to provide a heavy duty radial tyre, in which the resistance to uneven wear and tear-off, wet performance, and appearance or tread pattern's image are improved in a well balanced manner.

According to one aspect of the present invention, a heavy duty radial tyre comprises a tread portion which is provided with blocks having acute angled corners between a pair of edge lines, characterised in that the acute angled corners are provided with a down slop which becomes steeper from the radially outside to the inside of the tyre.

The angle may change step-by-step or gradually.

Preferably, the size of the slope is 1 to 10 mm when measured along the one edge line (3A), and 1 to 10 mm when measured along the other edge line (3B), and 5 to 13 mm when measured in the radial direction of the tyre.

Embodiments of the present invention will now be described in detail in conjunction with the accompanying drawings.

Fig.1 is a cross sectional view of a tyre of the present invention;
Fig.2 is a partial developed plan view of the tyre showing an example of the tread pattern;
Fig.3 is a plan view of a block;
Fig.4 is a partial perspective view of the blocks showing a corner thereof;
Fig.5 is a cross sectional view showing the slope thereof;
Fig.6 is a cross sectional view showing another example of the slope;
Fig.7 is a partial perspective view of another example of the block;
Fig.8 is a partial perspective view of still another example of the block;
Fig.9 is a cross sectional view showing the slope thereof;
Fig.10 is a perspective view of a blocks having edged corners;
Fig.ll is a perspective view for explaining the prior art;
Fig.12 is a cross sectional view showing the slope thereof; and
Fig.13 is a cross sectional view showing the slope of a test tyre.

In Fig.1, a heavy duty radial tyre 1 according to the present invention comprises a tread portion 15, a pair of sidewall portions 16, a pair of bead portions 17 each with a bead core 19 therein, a carcass 20 extending between the bead portions 17, and a belt 21 disposed radially outside the carcass 20 in the tread portion 15.

The carcass 20 comprises at least one radial or semiradial ply made of steel cords or organic fibre cords, e.g. polyester, aromatic polyamide rayon, nylon, or the like being arranged at an angle of from 70 to 90 degrees with respect to the tyre equator C and turned up around the bead cores 19 from the axially inside to the outside of the tyre.

The belt 21 comprises two to four plies including at least two crossed plies, each of which is made of organic fibre cords, e.g. nylon, polyester, rayon, aromatic polyamide or the like or steel cords laid in parallel with each other at a predetermined inclination angle with respect to the tyre equator C. In this example, four belt plies 21A, 21B, 21C and 21D are disposed, and the cord inclining direction is reversed between the belt plies 21B and 21C.

The tread portion 15 as shown in Fig.2 is provided with circumferential rows 12 of blocks 2 which are divided by circumferential grooves 23, 24 and 25 and axial grooves 26, and each block 2 has acute angled corners (B). By those tread grooves 23-26, the so called block type tread pattern is formed, which is however only an example of the tread pattern. It is possible to employ another type of tread pattern, for example, a combination of block rows and circumferentially continuously extending ribs.

According to the present invention, a down slope 9 which becomes steeper toward the radially innerside of the tyre is formed on the acute angled corners (B). Preferably all the acute angled corners (B) adjoining the circumferential grooves are provided with a down slope 9. It is however possible that some of the corners (B) are not provided with such a slope. It is also possible that all the acute angled corners existing in the tread are provided with such a slope.

In the example of Fig.2, a pair of main grooves 23 extending continuously in the tyre circumferential direction are disposed one on each side of the tyre equator C. A pair of narrow grooves 24 extending continuously in the tyre circumferential direction are each disposed between the tyre equator C and the main grooves 23. A pair of narrow grooves 25 extending continuously in the tyre circumferential direction are each disposed between the tread edge E and the main grooves 23; and axial grooves 26 are provided extending from the narrow grooves 24 to the tread edges E.

Therefore, a first row 12M of blocks 2A is formed between each of the narrow grooves 24 and the adjacent main groove 23; a second row 12N of blocks 2B is formed between each of the narrow grooves 25 and the adjacent main groove 23; a third row 12L of blocks 2C is formed between each of the narrow grooves 25 and the adjacent tread edge E; and a rib 31 extending continuously in the tyre circumferential direction along the tyre equator C is formed between the two narrow grooves 24.

The rib 31 is provided with sipes 27 extending from the axially inner ends of the axial grooves 26 to the tyre equator C and circumferentially displaced relative to one another, and sipes 29 extending on the tyre equator C between circumferentially adjacent sipes 27 to form zigzag sipes 30 as shown in Fig.2.

The main groove 23 is staggered at the crossing points with the axial grooves 26, and the segments between the axial grooves 26 are straight and inclined in one direction. Further, in the region between the narrow grooves 24 and 25, the axial grooves 26 are substantially straight and inclined in one direction. Furthermore, in the region between the narrow groove 25 and the tread edge E, the axial grooves 26 are straight and inclined in one direction which is different from the above-mentioned direction. As a result, the blocks 2A, 2B and 2C have a trapezoidal configuration. The trapezoid of the blocks 2A is reverse to that of the blocks 2B.

Thus, each of the blocks is provided on each side in the circumferential direction with one acute angled corner (B) which is defined between a circumferentially extending edge line 3A and an axially extending edge line 3B as shown in Fig.3.

In the example of Fig.2, the blocks 2A and 2B are provided on all the acute angled corners (B) with the down slope 9, but the blocks 2C are provided with the down slope 9 on acute angled corners (B) on the inner side of the axial direction. The acute angled corners adjoining the tread edges are not provided with a down slope.

Figs.4 and 5 show an example of the down slope 10 according to this invention. In this example, the slope 9 is a double slope composed of a radially outer gentle slope 9A and a radially inner steep slope 9B. The outer slope 9A is a trapezoidal flat plane, and the inner slope 9B is a triangle flat plane. Thus the slope 9 as a whole seems like a bent isosceles triangle.

Fig.6 shows another example of the slope 9. In this example, the slope 9 is a triple slope composed of the radially outer trapezoidal gentle slope 9A, the radially inner triangle steep slope 9B and a trapezoidal middle slopes 9C therebetween.

The slope 9 can be composed of four or more slopes.

Fig.7 shows still another example of the slope 9, which is a double slope similar to the former example of Fig.4, but the outer and inner slopes 9A and 9B are convexly curved in a horizontal plane parallel with the tread face.

Figs.8 and 9 shows still more another example of the slope 9. In this example, the slope 9 becomes steeper gradually in contrast to the above-explained step-by-step change. Further, the slope 9 is straight, not curved, in a horizontal plane in contrast to Fig.7.

It is also possible that the slope 9 is curved in a horizontal plane and a perpendicular plane like a combination of the examples of Fig.7 and Fig.8.

In the slopes 9, of which the angle changes step-by-step, the radially inner slope 9B preferably has an inclination angle αmin in the range of from 10 to 30 degrees. The radially outer slope 9A has an inclination angle $\alpha 1$ in the range of from 30 to 70 degrees. In case of a double slope, the angle $\alpha 1$ is preferably in the range of from 30 to 50 degrees. In case of a triple slope, preferably, the angle $\alpha 1$ is in the range of from 50 to 70 degrees, and the middle slope 9C has an inclination angle $\alpha 2$ in the range of from 30 to 50 degrees.

In the case of the curved slope of Fig.8, the inclination angle α gradually changes from substantially 90 degrees at the top to substantially 0 degree at the radially inner end point I.

Based on the above-explained angle change, the dimensions of the cut-off rubber, that is, the size of the slope 9 is defined as follows.

First, as shown in Figs.3-9, a point (A) and distances La, Lb and Lc relating to the slope size are defined beforehand. The point (A) is an intersecting point of the three edge lines 3A, 3B and 5 of the block 2. The distance La is between the point (A) and an intersecting point of the line 3A and the upper edge 7 of the slope 9. The distance Lb is between the point (A) and an intersecting point of the line 3B and the upper edge 7 of the slope 9. The distance Lc is a radial distance between the point (A) and the radially inner extreme end of the slope 9.

In other words, the distance Lc is the radial extent of the slope 9. The distance La is the distance between the radially inner extreme end of the slope 9 and the intersecting point of the edge line 3A and the upper edge 7 which distance is projected on the tread face. The distance Lb is the distance between the radially inner extreme end of the slope 9 and the intersecting point of the edge line 3B and the upper edge 7 which distance is projected on the tread face.

The distances La and Lb are preferably set in the range of from 1 to 10 mm, more preferably 3 to 6 mm. If the distances La and Lb are less than 1 mm, it becomes difficult to obtain the required resistance to uneven wear and tear-off. If the distances La and Lb are more than 10 mm, not only the wet performance is liable to be deteriorated but also the tread pattern becomes a bad image. For the similar reason, the distance La is preferably set in the range of from 0.05 to 0.15 times the block edge length LA, and the distance Lb is preferably set in the range of from 0.10 to 0.30 times the block edge length LB.

The distance Lc is preferably set in the range of from 0.25 to 0.50 times the blocks height LD and in the range of from 5 to 13 mm. If Lc is less than 5 mm or Lc/LD is less than 0.25, it becomes difficult to obtain the required resistance to uneven wear and tear-off. If Lc is more than 13 mm or Lc/LD is more than 0.50, not only the wet performance is liable to be deteriorated but also the tread pattern becomes a bad image.

The above-mentioned inclination angles α, $\alpha 1$, $\alpha 2$, amin of the slopes 9 are defined as an angle of a tangential line to the slope 9 measured with respect to a perpendicular line L, wherein both the lines are in a perpendicular plane F which is at a right angle to the slope 9 in a horizontal plane.

If the angle α is less than the above-mentioned range, the resistance to uneven wear and tear-off is liable to decrease. If the angle α is over the above-mentioned range, the resistance to uneven wear and tear-off and tread pattern's image becomes worse.

Comparison Tests

Test tyres of size 285/75R24.5 having the same internal structure as shown in Fig.1 and the tread pattern of Fig. 2 were made and tested. The carcass was composed of a single radial ply of steel cords (3/0.20+7/0.23), and the belt was composed of four plies of steel cords (1X3/0.20+6/0.35). The other specifications and test results are shown in Table 1.

1) Tread pattern image test

The tread pattern image was evaluated into five ranks (larger is better) on the basis of a feeling whether the acute angle corners are seen to be sharp or dull.

2) Resistance to uneven wear test

A 2-D·D truck provided on the rear wheels with test tyres was run for 100,000 km on dry paved roads. Then the average of the maximum wear of the blocks 2A and 2B was obtained and ranked as follows. Rim size: 8.25X24.5, Tyre load: 2800 kg, Inner pressure: 7.5 kgf/sq.cm

Rank	Wear (mm)
5+	0 - 0.4
5-	0.5- 0.9
4+	1 - 1.4
4-	1.5- 1.9
3+	2 - 2.4
3-	2.5- 2.9
2	3 - 4.9
1	5 -

3) Wet performance test

The time necessitated to make a predetermined number of turns in a wet basalt stone paved circular test course was measured and ranked into five ranks (larger is better).

4) Resistance to tear-off test

After the above test 3), the blocks are examined whether the blocks were torn off or not, and the size of the torn-off rubber was evaluated and the number of torn-off corners was counted as follows.

Rank Size (mm)		Number
1	over 7X7X7	20 -
2	over 7X7X7	6 - 19
3-	over 7X7X7	3 - 5
3+	over 7X7X7	1 - 2
4-	over 3X3X3	9 -
4+	over 3X3X3	6 - 8
5-	over 3X3X3	3 - 5
5+	over 3X3X3	0 - 2

It was confirmed that the example tyres according to the present invention were improved in the performance as a whole in comparison with the reference tyres.

As described above, in the heavy duty radial tyre according to the present invention, the resistance to uneven wear and tear-off, wet performance, and pattern's image can be improved in a well balanced manner.

Table 1

	Example																										Reference					
Tire	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	1	2	3	4	5	6
Slope (Fig.No.)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	9	12	12	12	12	13	10
Number	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3		1	1	1	1	2	0
Angle																																
$\alpha 1$ (deg)	39	56	27	30	39	39	39	39	56	56	33	45	27	27	56	56	68	45	35	55	75	45	68	68	35	-	-	-	-	-	-	-
$\alpha 2$ (deg)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45	27	19	27	45	33	55	45	19	-	-	-	-	-	-	-
αmin (deg)	16	37	14	22	16	16	16	16	37	37	14	37	9	11	37	37	27	18	11	18	27	18	27	33	9	-	-	-	-	-	-	-
θ (deg)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	27	7	63	-	-
$\beta 1$ (deg)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-
$\beta 2$ (deg)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45	-
La (mm)	3	6	2	3	6	1	2	7	6	6	2	6	2	2	9	11	6	3	2	3	6	3	6	6	2	6	3	6	2	6	3	-
Lb (mm)	3	6	2	3	6	1	2	7	6	6	2	6	2	2	9	11	6	3	2	3	6	3	6	6	2	6	3	6	2	6	3	-
Lc (mm)	6	6	6	6	12	6	6	6	4	14	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	12	12	3	6	-
Pattern's Image	5	4	5	4	4	5	5	4	4	4	4	5	5	5	4	4	4	4	5	4	4	4	4	4	5	5	4	3	5	4	4	5
Uneven wear	5+	5-	4-	4+	5+	4-	4+	5+	4+	5+	5+	5+	3+	4-	4-	4+	5+	4+	3+	4-	4+	5-	4+	5-	3-	5+	3+	4+	2	2	3+	1
Wet performance	5	5	5	4	4	5	5	4	5	4	5	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	4	3	5	5	3	5
Tear-off	5+	5-	4-	5+	5+	4-	4+	5+	4+	5+	5+	5+	3+	4-	4-	4+	5+	4+	3+	4-	4+	5-	4+	5-	3-	5+	3+	4+	2	2	3+	1

Claims

1. A heavy duty radial tyre comprising a tread portion (15) provided with blocks (2) having acute angled corners (B) between a pair of edge lines (3A and 3B), characterised in that the acute angled corners (B) are provided with a down slope (9) which becomes steeper from the radially outside to the inside of the tyre.

2. A heavy duty radial tyre according to claim 1, characterised in that the angle of the slope (9) changes step-by-step.

3. A heavy duty radial tyre according to claim 2, characterised in that the slope (9) comprises a radially outer gentle slope (9A) having one angle al of from 30 to 70 degrees to the radial direction, and a radially inner steep slope (9B) having one angle αmin of from 10 to 30 degrees to the radial direction.

4. A heavy duty radial tyre according to claim 1, characterised in that the angle of the slope (9) changes gradually.

5. A heavy duty radial tyre according to claim 4, wherein the angle of the slope changes gradually from 90 to 0 degrees to the radial direction.

6. A heavy duty radial tyre according to any of claims 1 to 5, characterised in that the size of the slope (9) is 1 to 10 mm along the one edge line (3A), 1 to 10 mm along the other edge line (3B), and 5 to 13 mm in the radial direction of the tyre.

Fig.1

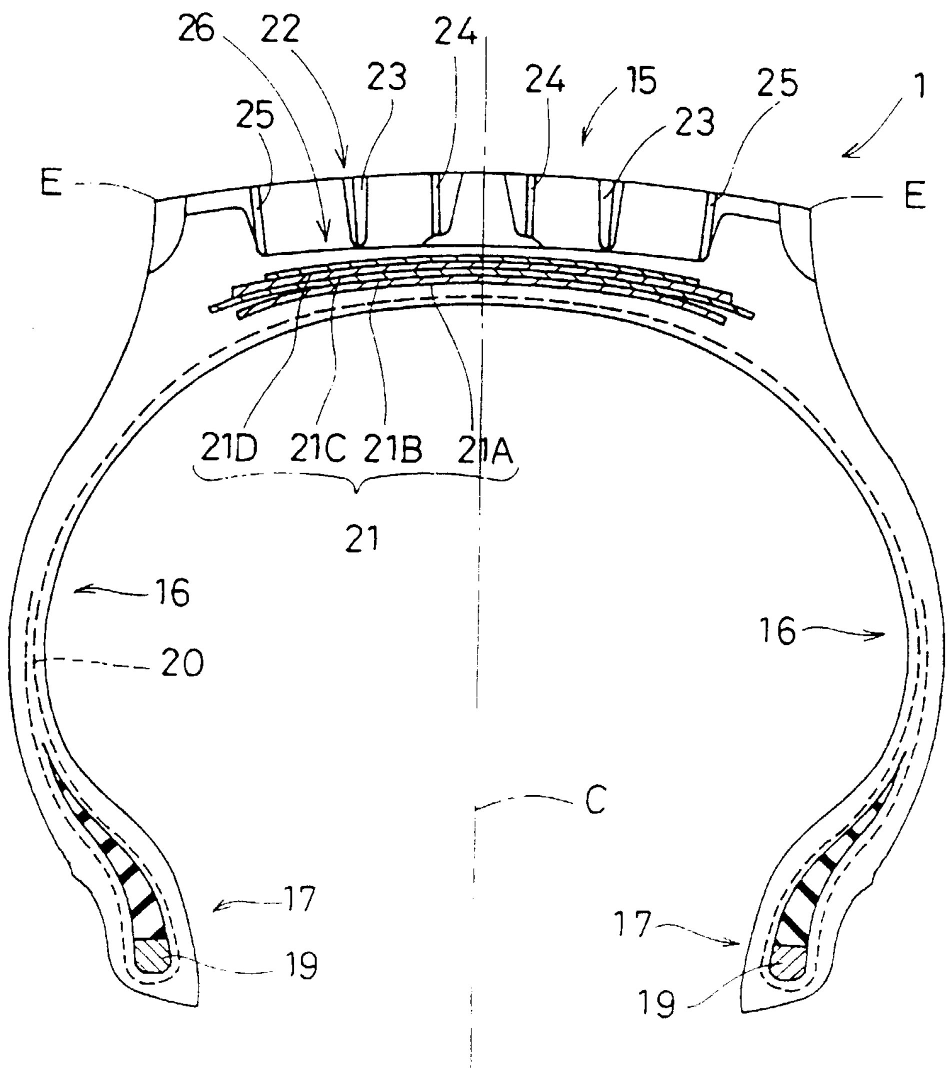
26
22
24
23
24
15
25
1
25
23
E
E
21D
21C
21B
21A
21
16
16
20
C
17
17
19
19

Fig.2

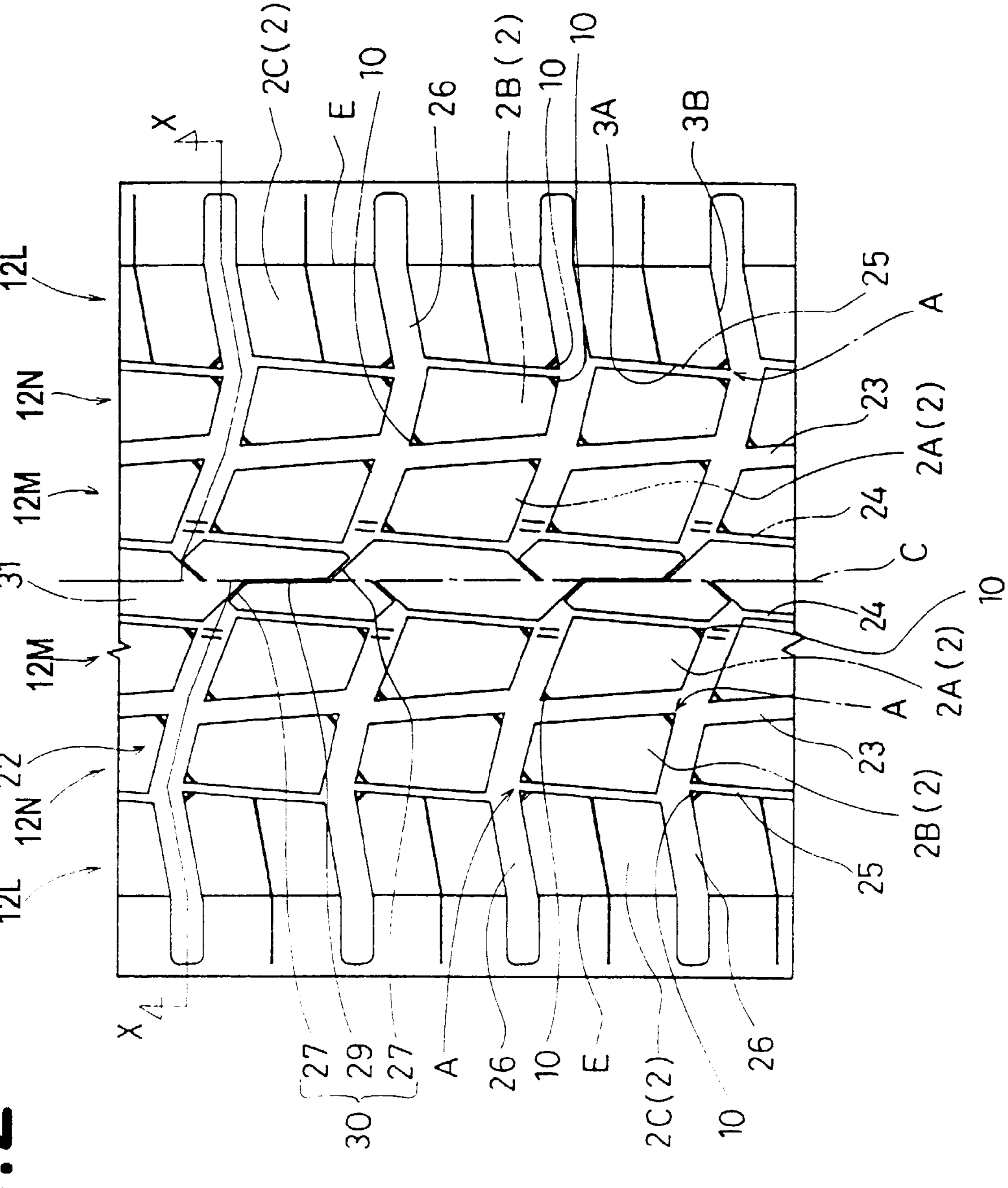

Fig.3

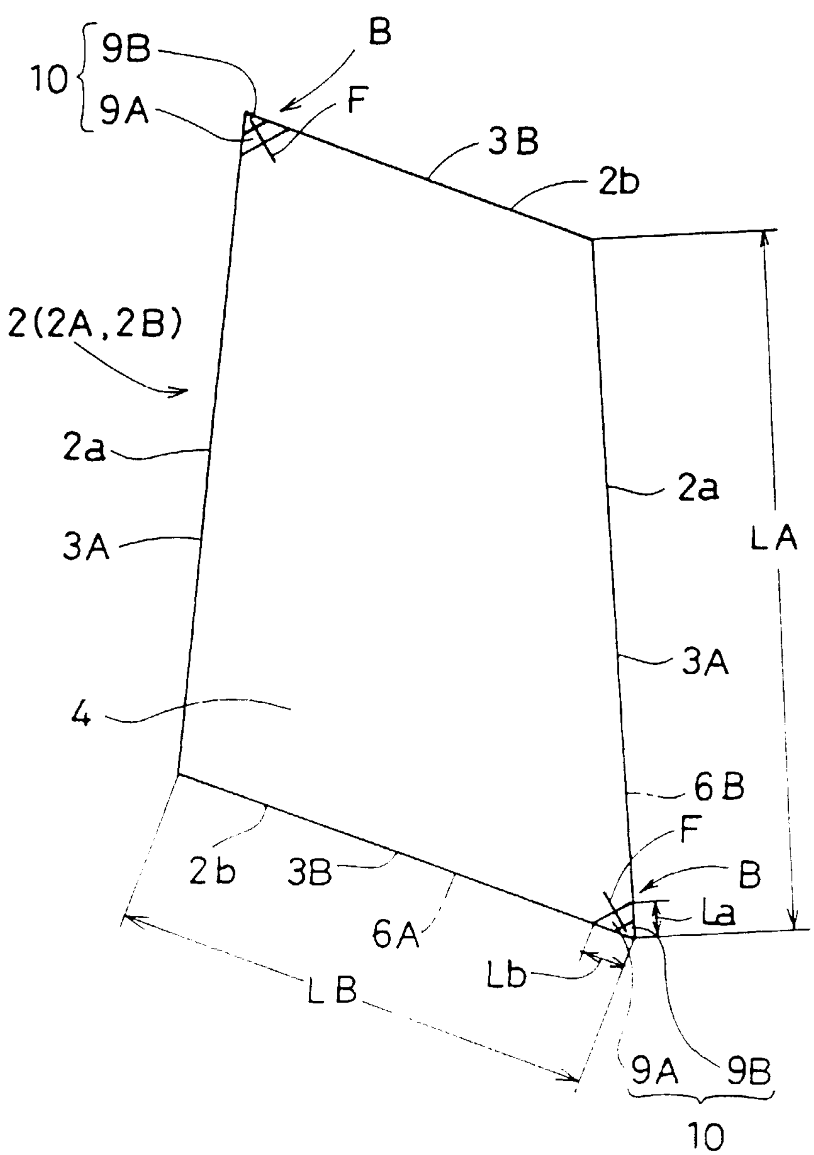
10
9B
9A
B
F
3B
2b
2(2A,2B)
2a
3A
4
2a
LA
3A
6B
F
B
La
2b
3B
6A
LB
Lb
9A
9B
10

Fig.4

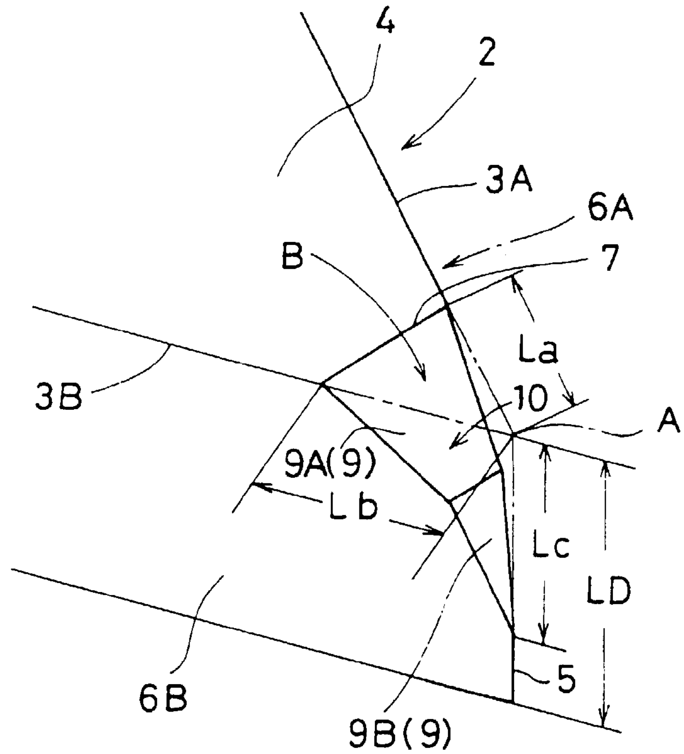
4
2
3A
6A
B
7
La
3B
10
A
9A(9)
L b
Lc
LD
6B
5
9B(9)

Fig.5

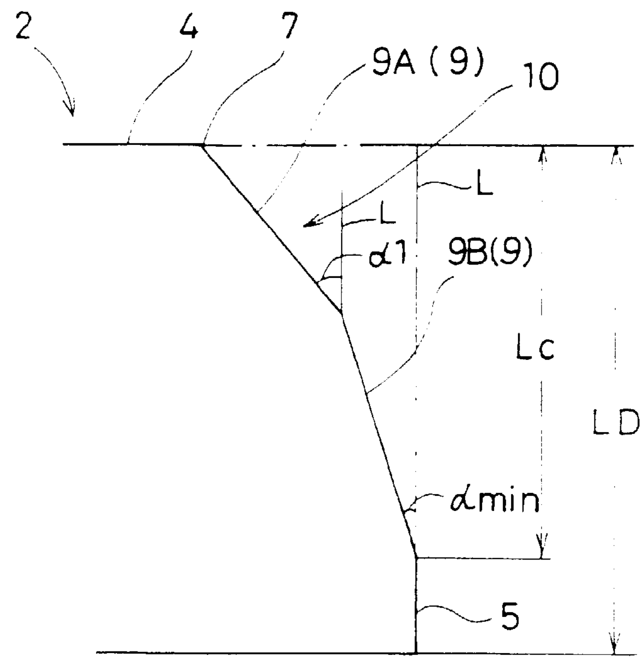
2
4
7
9A (9)
10
L
L
α1
9B(9)
Lc
LD
αmin
5

Fig.6

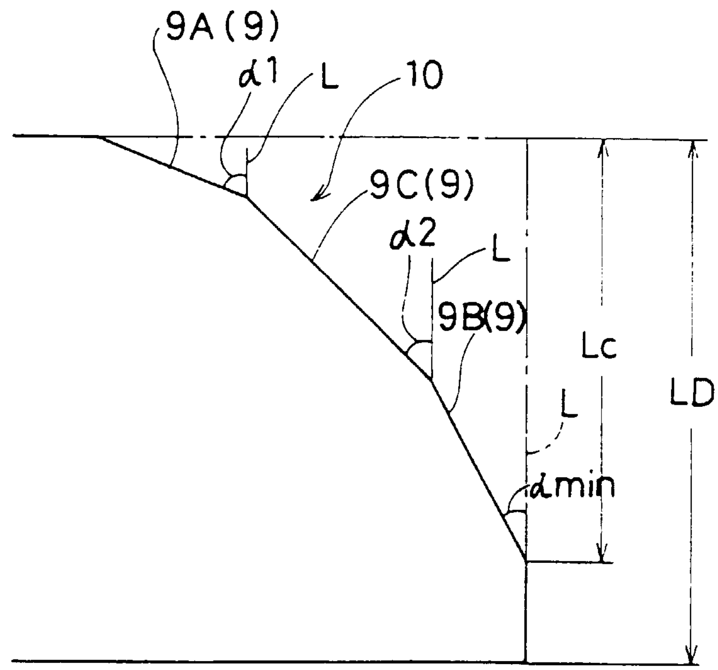

Fig.7

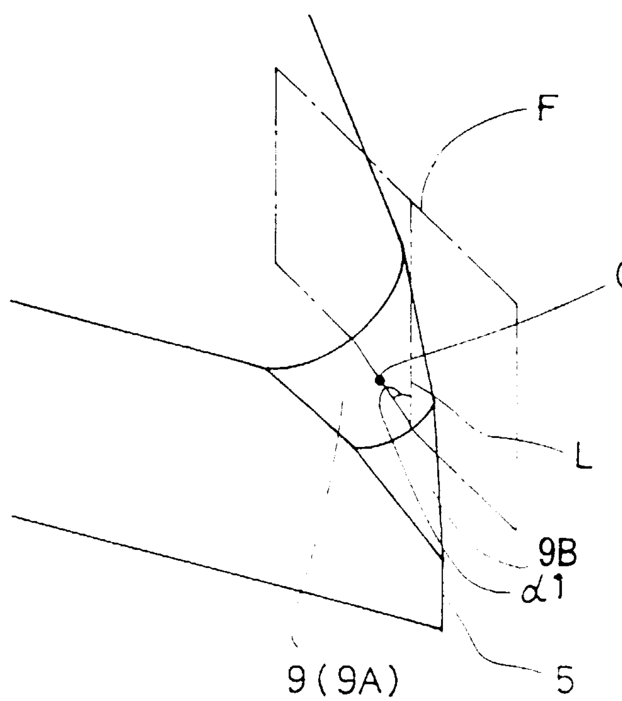

Fig.8

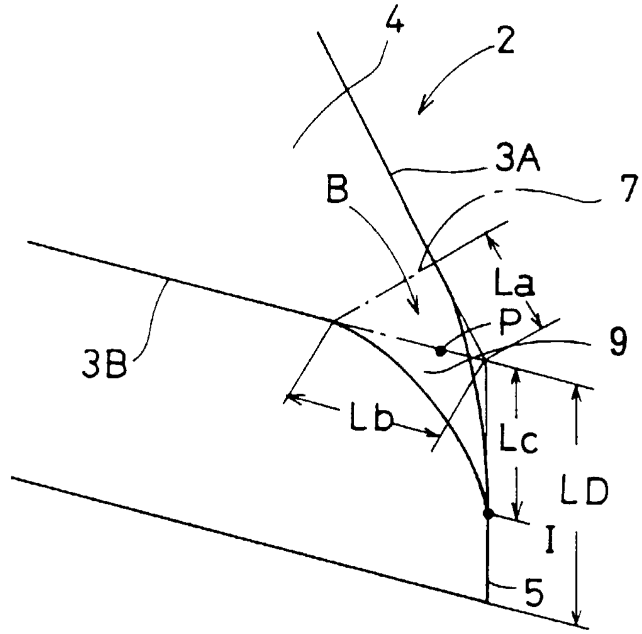

Fig.9

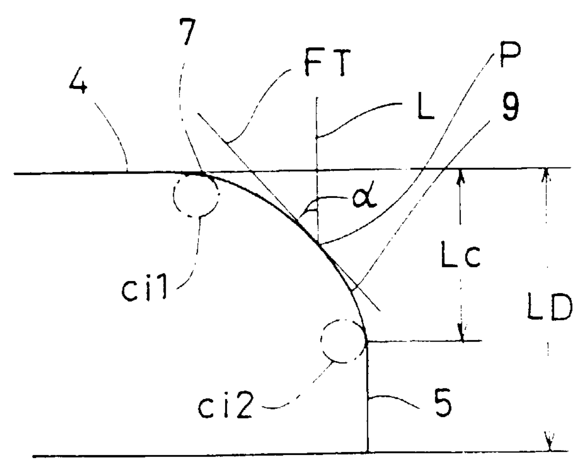

Fig.10

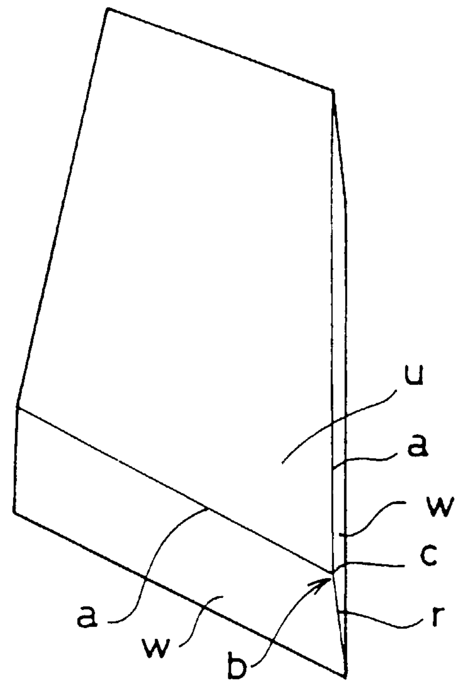

Fig.11

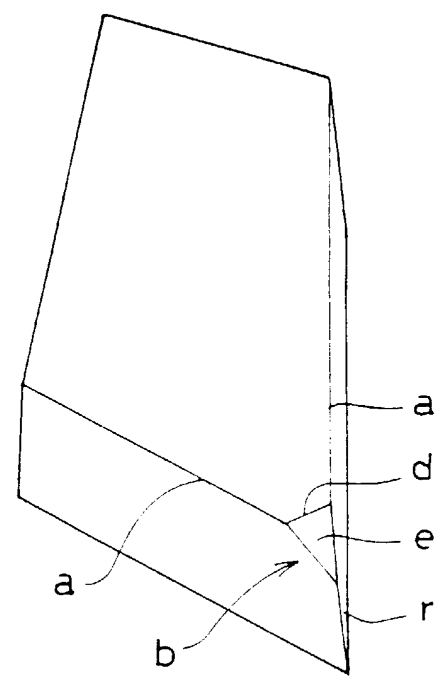

Fig.12

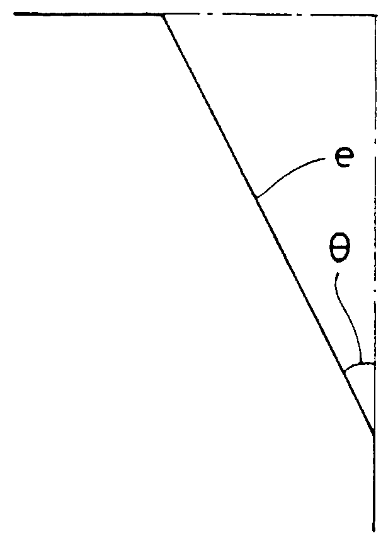

Fig.13